STATE OF ILLINOIS
WILLIAM G. STRATTON, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
VERA M. BINKS, *Director*

DIVISION OF THE
STATE GEOLOGICAL SURVEY
JOHN C. FRYE, *Chief*
URBANA

REPORT OF INVESTIGATIONS 195

PRELIMINARY REPORT ON PORTLAND CEMENT MATERIALS IN ILLINOIS

BY

J. E. LAMAR, J. S. MACHIN, W. H. VOSKUIL, AND H. B. WILLMAN

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS

1956

STATE OF ILLINOIS
WILLIAM G. STRATTON, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
VERA M. BINKS, *Director*

DIVISION OF THE
STATE GEOLOGICAL SURVEY
JOHN C. FRYE, *Chief*
URBANA

REPORT OF INVESTIGATIONS 195

PRELIMINARY REPORT ON PORTLAND CEMENT MATERIALS IN ILLINOIS

BY

J. E. LAMAR, J. S. MACHIN, W. H. VOSKUIL, AND H. B. WILLMAN

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS

1956

ORGANIZATION

STATE OF ILLINOIS
HON. WILLIAM G. STRATTON, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
HON. VERA M. BINKS, *Director*

BOARD OF NATURAL RESOURCES AND CONSERVATION

GEOLOGICAL SURVEY DIVISION

JOHN C. FRYE, PH.D., D.SC., *Chief*

(32274—2500—2-56) 2

CONTENTS

	Page
Economic aspects of the cement industry	5
Cement technology and chemistry	6
The manufacturing process	6
Chemical constitution	7
Cement raw materials	7
Illinois materials for portland cement making	9
Definitions	9
District 1	12
District 2	14
District 3	18
District 4	20
District 5	24
References	34

ILLUSTRATIONS

Figure		Page
1.	Generalized columnar section of the bedrock formations in Illinois	10
2.	Generalized geologic map of Illinois	11
3.	Districts discussed	13

TABLES

		Page
1.	Shipments and production of cement	6
2.	Cement manufacturing plants	6
3.	Sources and chemical analyses of samples	26

PRELIMINARY REPORT ON PORTLAND CEMENT MATERIALS IN ILLINOIS

BY

J. E. LAMAR, J. S. MACHIN, W. H. VOSKUIL, AND H. B. WILLMAN

ABSTRACT

Many parts of Illinois contain limestone and clay or shale that may be of suitable chemical composition for cement making. The importance of these resources depends on the location of deposits satisfactory for commercial development in areas having a favorable market outlet.

This report discusses the economic situation of the manufacture of portland cement in Illinois, with special reference to the manufacturing process, the chemical constitution, and the nature of the raw materials. The geology, occurrence, and suitability of cement raw materials are listed by geographic district. Sources and chemical analyses of about 125 samples are given.

This report has been prepared in response to repeated requests for information relating to the possibility of establishing additional portland cement plants in Illinois. It includes a discussion of the economics of the cement industry in Illinois and adjacent states and of cost factors relating to new plants. The manufacture of portland cement and the character of the raw materials used in cement making are described briefly. The rock formations of Illinois, their areas of outcrop, and their chemical character are also broadly indicated. Together these data permit an evaluation of the general possibilities for cement plants in various parts of the State.

W. H. Voskuil prepared that portion of the report on the economic aspects of the cement industry, J. S. Machin the discussion of cement technology and chemistry, and J. E. Lamar and H. B. Willman the description of the earth materials of Illinois. Other members of the Survey staff have also contributed to the report—especially D. H. Swann, C. W. Collinson, M. E. Ostrom, and J. A. Simon.

ECONOMIC ASPECTS OF THE CEMENT INDUSTRY

The manufacture of cement is the fourth-largest mineral industry in Illinois. In 1953, the latest year for which detailed data are available, output exceeded all previous records and was 4 percent above the 1952 output. Capacity of Illinois plants in 1953 was rated at 9,752,230 barrels (376 pounds per barrel). The industry operated at 92.9 percent capacity. Producers, in decreasing capacity, are Marquette Cement Manufacturing Co., Oglesby; Medusa Portland Cement Co., Dixon; Alpha Portland Cement Co., LaSalle; and Lehigh Portland Cement Co., Oglesby.

Consumers of large quantities of cement —for instance, the Federal Government— buy directly from the producer on a contract price. Users of smaller amounts buy from local dealers, who stock the commodity for the convenience of the locality and will sell as small a quantity as a single bag. The industry is highly competitive in the many localities where there are a number of mills within shipping radius.

The manufacture of cement is a large-scale operation involving a heavy investment in plant and quarry. Capacities of plants in Illinois and neighboring states range from 1,120,000 barrels to more than 7 million barrels. An individual plant, therefore, appears to have a capacity of from one-sixth to nearly one-half of Illinois' cement consumption. In 1951, for example, 155 plants in the United States had an average production of 1,600,000 barrels and shipped an average of $4,000,000 of cement.

"The cost of constructing new plants has risen steeply in recent years, and estimates of cost of a new plant now range from $9 to $12 per annual barrel capacity, with the minimum annual economic capacity in the neighborhood of 1 million barrels. Most portland cement producers have expanded capacity by improving and enlarging their crushing, grinding and kiln departments wherever possible in preference to erecting new plants" (North, 1954).

The success of a plant depends upon the market outlet obtainable for its product when the plant is operating near capacity. As transportation is an important element in the delivered cost of cement, the success of a plant depends upon a large market in its vicinity, or upon having available to it low-cost transportation facilities (e.g., bulk water transportation by barge), which gives it a competitive advantage over rival plants.

Cement is both exported from Illinois to neighboring states and imported from neighboring states. The net balance in 1953 was an import of 2 percent. The principal sources of cement from outside Illinois are the mills in northern Indiana and eastern Missouri. The principal outlets for Illinois cement to neighboring states are Wisconsin, Minnesota, and Iowa, in the order named.

Shipments from mills in Illinois and two important competing states, together with estimated consumption and surplus or deficiency are given in table 1.

The principal mode of transportation is by rail although barge shipments on the Illinois-Mississippi Waterway also are significant. Truck transportation is increasing for local or short-haul markets.

Table 1.—Shipments and Production of Cement*
(barrels)

	Shipments	Estimated consumption	Surplus or deficiency
Illinois			
1951 . .	8,377,387	12,286,321	−3,908,934
1952 . .	8,710,621	13,324,065	−4,613,444
Iowa			
1951 . .	8,024,492	4,948,576	+3,075,906
1952 . .	9,336,727	4,976,010	+4,360,717
Missouri			
1951 . .	10,217,421	5,663,459	+4,553,962
1952 . .	10,086,850	6,319,588	+3,767,262

*Minerals Yearbook, U. S. Bureau of Mines, 1952.

Table 2.—Cement Manufacturing Plants in Illinois and Bordering States in 1956*

	Capacity (barrels)
Illinois	
Dixon: Medusa Portland Cement Company	2,500,000
LaSalle: Alpha Portland Cement Company	1,600,000
Oglesby: Marquette Cement Manufacturing Company	4,250,000
Oglesby: Lehigh Portland Cement Company	1,120,000
Indiana	
Buffington: Universal Atlas Cement Company	7,000,000
Limedale: Lone Star Cement Company	2,600,000
Mitchell: Lehigh Portland Cement Company	1,700,000
Speed: Louisville Cement Company .	2,500,000
Kentucky	
Kosmosdale: Kosmos Portland Cement Company	2,000,000
Missouri	
Cape Girardeau: Marquette Cement Manufacturing Company	1,800,000
Hannibal: Universal Atlas Cement Company	†
Prospect Hill: Missouri Portland Cement Company.	5,000,000
St. Louis: Alpha Portland Cement Company	1,900,000
Iowa	
Davenport: Dewey Portland Cement Company	2,750,000

*Pit and Quarry, v. 48, no. 8, p. 176, February, 1956, and map, "Portland cement plants in the United States and Mexico," Pit and Quarry Publications, 1956.
†Figures not available.

CEMENT TECHNOLOGY AND CHEMISTRY

Portland cement has been defined in various ways. One definition states that it is a finely pulverized material consisting of certain definite compounds of lime, alumina, and silica, which when mixed with water has the property of combining slowly with the water to form a hard, solid mass.

The Manufacturing Process

Cement is made by crushing and grinding to a fine (200 mesh) powder a mixture of a calcareous material (limestone) and an argillaceous material (shale or clay), plus relatively small amounts of other materials, usually some form of iron oxide, and heating the mixture until certain chemical interactions have taken place. The chemical composition of the mixture must be controlled within narrow limits or the cement will not meet specifications.

The burning is done in rotary kilns, which range up to 12 feet in diameter and 500 feet in length. The fuel may be powdered coal, gas, or oil. Its ash must be considered in the calculation of the composition of the kiln feed. The product of the kiln is sintered gray-to-black lumps called clinker. The clinker is cooled and ground to the required fineness with the addition of small amounts of gypsum. Sometimes other materials are added, as, for instance, when the cement is to be used for air-entrained concrete. The resulting powder, which must meet definite chemical and physical specifications, is called portland cement.

Chemical Constitution

An inspection of a number of chemical analyses of American-made cements shows oxide content about as follows:

	Range		*Average*
SiO_2	19.4% to	25.5%	22.45
CaO	60.2	65.0	62.6
Al_2O_3	3.4	9.2	6.3
Fe_2O_3	1.2	5.0	3.1
MgO	.3	3.4	1.85
SO_3	.4	2.3	1.35
Ign. loss	.7	2.5	1.6

The following analysis is probably fairly typical of a type I cement intended for general concrete construction when no special properties are required.

SiO_2	21.3
CaO	63.2
Al_2O_3	6.0
Fe_2O_3	2.7
MgO	2.9
SO_3	1.8
Ign. loss	1.3
	99.2

Cement Raw Materials

As in most industrial-type chemical processes, many factors must be carefully considered in order to engineer the process not only so that the best product will result, but so that the cost will permit the product to compete in the market. Ideally, raw material sources should meet a host of requirements. Practically, some compromises must usually be made depending on materials available, location with respect to mill and market, and similar considerations. It is not enough that the selected raw materials be such that on calcination or burning there will result a material meeting the specifications. A most important requisite for a raw material for a cement mill is that it be available in large amounts and that it be as uniform in composition as possible. If it is not uniform, frequent chemical analysis will be required and readjustment of the proportions of raw materials in accordance with these analyses will be necessary. These analyses are expensive, and the adjustments are apt to result in operating troubles and production losses.

The raw materials, in the order of importance as judged by quantity consumed in this country, are limestone, cement rock, clay and shale, gypsum, blast-furnace slag, sand and sandstone, iron materials (ore and millscale), and small amounts of other materials. Some types of raw materials, even though they are suitable from the chemical-analysis viewpoint, may contain constituents that have physical or chemical characteristics that make them unacceptable. A common example of this is material that contains considerable quantities of chert, which chemically is much like sand or sandstone but which is hard to grind and does not react easily with other constituents at the temperatures prevalent in commercial cement kilns.

Limestone (including oyster shells, which can be used) constitutes approximately three-fourths of the total raw material that goes into the average cement. To produce a barrel of cement (376 pounds) approximately 655 pounds of raw materials, excluding fuel, are required. To determine whether a limestone is suitable for making cement, consideration must be given not only to the properties of the limestone itself, but to those of supplementary materials available. The principal supplementary material will in all probability be some type of shale or clay. As the finished cement will analyze 60 to 65 percent calcium oxide, the limestone must have sufficient calcium carbonate to supply this. This means that to produce a thousand pounds of cement, enough limestone to yield 600 to 650 pounds of calcium oxide must be blended in the mix, assuming that all the calcium oxide comes from the limestone and none from the other raw materials, which is essentially the case. If the limestone is 97 percent calcium carbonate, i.e., if it is a good grade of high-calcium limestone, 1100 to 1200 pounds of limestone will be needed. If the limestone is lower in calcium carbonate, proportionately more will be needed.

The most critical specification from the chemical viewpoint is low magnesium oxide. As the specifications require that the magnesia content of the finished cement shall not exceed 5 percent by weight, the average magnesia content of the raw material blend must be 3 percent or less. Because limits are set in the specifications on SO_3 content, the amounts of pyrite and/or gypsum that can be tolerated in the limestone are limited. Although A.S.T.M. specifications make no mention of phosphate, it has been reported to be harmful because it caused burning difficulties and erratic setting qualities in the finished cement. Alkalies, like phosphates, are not mentioned in the specifications, but are reported to react with some types of concrete aggregate in such manner as to cause harmful expansion.

The limits of impurity that can be tolerated depend on the nature of the impurity. The range of oxide content of cement given above indicates that the calcium oxide/silica ratio ranges from 2.55 to 3.10. This would mean that if the total impurity were silica, the limestone would need to be at least 77 percent calcium carbonate in order to maintain the lime/silica ratio required. Actually it would need to be considerably higher than this because of the dilution necessary in the addition of other materials to meet the requirements for Fe_2O_3 and Al_2O_3. If the impurity is argillaceous in character, the situation is better because in this case the impurities would contribute Al_2O_3 and Fe_2O_3 and relatively less silica.

To summarize the characteristics to be looked for in a limestone that is to be used as the basic raw material in the manufacture of cement, some questions to be asked are: Is the amount available sufficient for a reasonable period of operation? Is the deposit sufficiently uniform? Is the magnesium oxide content below 3 percent? Is the lime/silica ratio high enough so that the ratio will be between 2.5 and 3.0 after the necessary additions of alumina and iron-bearing materials? Is the nature of the impurities such that the burning characteristics will be satisfactory? If the impurities are argillaceous (i.e., clayey), the chances are that the answer to this last question will be yes; if they are highly siliceous, the deposit is probably not usable.

Cement rock is impure limestone, usually argillaceous, which can be burned as it is, or with minor alterations, to make cement. In the early days of the industry such materials were used almost without addition. The character of the impurities may rule out the use of the rock because it may affect adversely the burning characteristics of the blend. The lime/silica ratio may be such as to make it useless, especially if suitable high-calcium materials are not available for blending to adjust this ratio. Sometimes under favorable circumstances an impure limestone may be beneficiated by mineral dressing methods in such a way that it becomes an acceptable cement raw material, but this is done only in exceptional cases.

Clay and shale, and in special instances sand and sandstone, are used to adjust the composition and control the burning characteristics of the blend. A mixture of lime alumina and silica probably could be burned to make good cement clinker, but the combination of temperature and time required would make it uneconomical. If the blend is too refractory, the time of retention in the kiln and/or the temperature required to bring about formation of the essential chemical compounds will be too great. If it is not sufficiently refractory, too large a part of the blend will fuse or become liquid. This will result in operating troubles and excessive wear on the kiln lining. The critical question about a clay or shale is whether or not its composition is such that it will lend itself to combination with the limestone or cement rock so as to produce the desired analysis in the clinker. If used in combination with high-calcium limestone it should have, ideally, a silica/alumina ratio of about 3.5.

Iron materials may or may not be used in the blend depending on the character of the other raw materials used and the properties desired in the finished cement. Various types of iron ore or millscale are used. The latter is an oxide of iron and, as is suggested by its name, is the material that scales off steel during the hot rolling process. The material used in any given case will be determined mainly by availability and price. Occasionally it may be advantageous to use fly ash from a steam power plant.

Iron blast-furnace slag is an attractive material for cement making for several reasons. First, it has already been heated, so that the volatile constituents have been driven off; hence it is economical from the standpoint of fuel consumption. Second, it contains all the necessary constituents. The composition of slag in the United States is usually higher in silica and lower in lime than is required for good cement clinker. It is therefore common to blend the slag with high-calcium limestone.

ILLINOIS MATERIALS FOR PORTLAND CEMENT MAKING

Rock materials occur in Illinois in great diversity and crop out at many places. The following discussion is intended to give general information regarding the nature of these formations, the general area wherein they crop out, and their chemical composition. A considerable variety of materials exists in many areas, which makes possible a number of combinations. These combinations are so numerous in Illinois that it is impractical to discuss them individually. However, a preliminary evaluation of their cement-making potential is possible on the basis of the data that follow and previous discussions of the economics and composition of materials for cement making.

The earth materials fall into two general categories—the bedrock and the surficial materials. The former include limestone, dolomite, dolomitic limestone, sandstone, shale, siltstone, coal, underclays, chert, and other high-silica rocks. The surficial materials include clay, silt, sand, and gravel. Certain types of some of these materials are called loess, glacial till, alluvium, and residual clays.

Of the bedrock materials, limestone, shale, the underclays of coals, and some siltstones are of principal interest as portland cement raw materials. The other bedrock materials listed can be eliminated, except in special instances, because they contain too much magnesia or silica.

Sandstone is used in some places as a component of the mix for cement making. Illinois sandstone formations are listed subsequently but not described because sandstones are normally a relatively minor component of the mix, if used at all, and are available in many parts of Illinois.

Among the surficial materials, some residual and other clays, some clayey alluvium, and the clay-enriched weathered zones on loess and till may be useful, but many of these materials probably do not have a suitable chemical composition.

Definitions

A number of terms are used in describing the rocks of Illinois, which, although generally understood, are defined to indicate their usage herein.

Limestone—rock consisting largely of the mineral calcite. This mineral is composed of calcium carbonate.

Dolomite—rock similar in appearance to limestone but consisting largely of the mineral dolomite. This mineral is composed of calcium carbonate and magnesium carbonate. The latter may comprise a maximum of about 46 percent of the rock.

Dolomitic limestone—rock intermediate in composition between limestone and dolomite.

Chert—rock consisting principally of microcrystalline silica; often popularly called *flint*.

SYSTEM	SERIES, GROUP, OR FORMATION		FEET
QUATERNARY	PLEISTOCENE SERIES - GLACIAL DRIFT		75
TERTIARY	PLIOCENE SERIES - "LAFAYETTE" GRAVEL		20
	EOCENE SERIES - WILCOX SAND		125
	PALEOCENE SERIES - PORTERS CREEK CLAY		100
CRETACEOUS	GULF SERIES - McNAIRY SAND		200
PENNSYLVANIAN	McLEANSBORO GROUP		1000
	CARBONDALE GROUP		250
	TRADEWATER GROUP		450
	CASEYVILLE GROUP		200
MISSISSIPPIAN	CHESTER SERIES		1000
	MERAMEC GROUP	STE GENEVIEVE LIMESTONE ST LOUIS LIMESTONE SALEM LIMESTONE	500
	OSAGE GROUP	WARSAW SHALE KEOKUK LIMESTONE BURLINGTON LIMESTONE FERN GLEN LIMESTONE	400
	KINDERHOOK GROUP		150
DEVONIAN	NEW ALBANY SHALE		100
	ALTO LIMESTONE LINGLE LIMESTONE GRAND TOWER LIMESTONE	CEDAR VALLEY - WAPSIPINICON LS	250
	CLEAR CREEK CHERT		300
	BACKBONE LIMESTONE		250
	BAILEY LIMESTONE		400
SILURIAN	NIAGARAN SERIES		300
	ALEXANDRIAN SERIES		100
ORDOVICIAN	MAQUOKETA SHALE		150
	GALENA (KIMMSWICK) DOLOMITE		200
	PLATTIN (PLATTEVILLE) LIMESTONE		150
	ST PETER SANDSTONE		100 - 500
	PRAIRIE du CHIEN SERIES	SHAKOPEE DOLOMITE	150
		NEW RICHMOND SANDSTONE	100
		ONEOTA DOLOMITE	200
CAMBRIAN	TREMPEALEAU DOLOMITE		200
	FRANCONIA DOLOMITE		100
	GALESVILLE SANDSTONE		200
	EAU CLAIRE SHALE		400
	MT SIMON SANDSTONE		1500-2000
PRE-CAMBRIAN	CRYSTALLINE ROCKS		

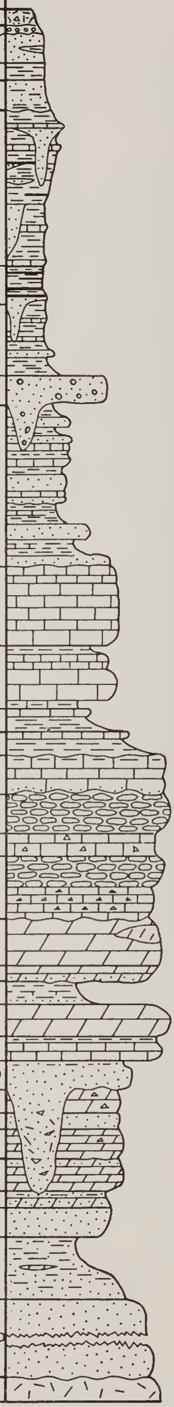

FIG. 1.—Generalized columnar section of the bedrock formations in Illinois. Thickness figures are approximate averages for areas in which the formations form the bedrock surface. The formations beneath the Franconia do not crop out. *From* Lamar, J. E., and Willman, H. B., 1955, Illinois building stones: Illinois Geol. Survey Rept. Inv. 184, fig. 2.

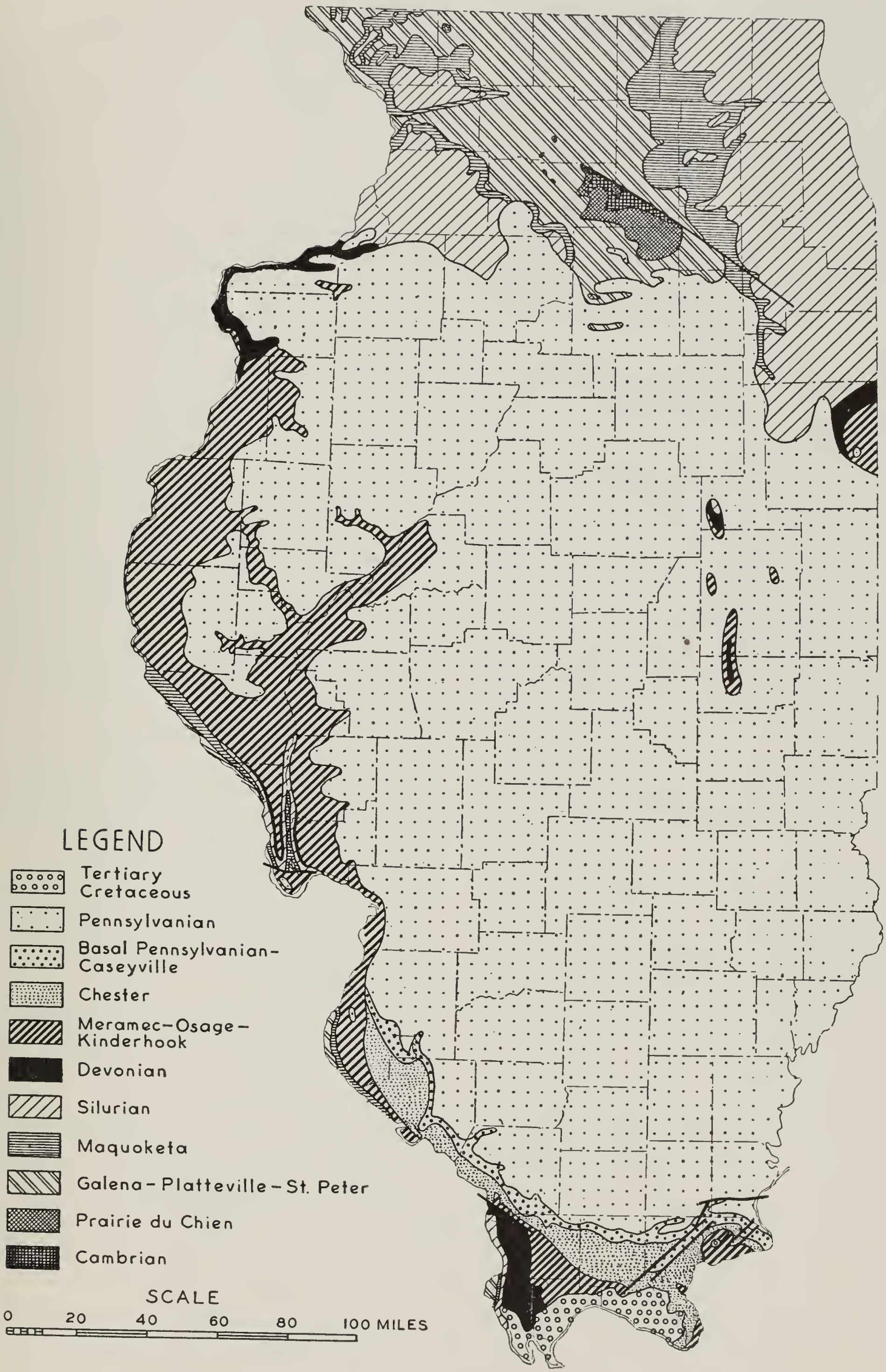

Fig. 2.—Generalized geologic map of Illinois (1945) showing the distribution of bedrock formations as they would appear if surficial materials were removed. *From* Horberg, Leland, 1950, Bedrock topography of Illinois: Illinois Geol. Survey Bull. 73, fig. 7.

Silt—unconsolidated earth material composed of particles of intermediate size between clay and sand; largely silica in composition although many deposits contain lesser amounts of clay and/or carbonates.

Siltstone—consolidated rock composed principally of silt.

Shale—consolidated rock, usually in thin layers, composed largely of clay, but commonly containing much silt; the clay is a complex mixture of hydrous aluminum silicates.

Loess—wind-deposited silt, usually brown; largely a calcareous and dolomitic silt where fresh and a clayey silt where weathered.

Till—silt or silty clay containing sand grains, pebbles, and boulders in varying amounts. Till is a deposit made by glaciers which once covered most of Illinois. The fresh material is highly variable but commonly contains dolomite.

Alluvium—deposits of clay, silt, sand, or gravel made by streams. The chemical composition of these deposits is highly variable.

Formation—term used to describe a sequence of rock layers mostly of similar composition, constituting an extensive natural unit.

Numerous formations crop out in Illinois and have been given identifying names. Throughout most of central Illinois these formations are principally sandstone, siltstone, shale, and clay with a lesser number of coal and limestone formations. Many of the latter are comparatively thin. Limestones are not common in the northern one-fifth of the State, but dolomite, sandstone, shale, or clay crops out at many places. In the marginal areas along the Mississippi and Illinois rivers in western Illinois, the Mississippi River in southwestern Illinois, and the Mississippi and Ohio rivers in extreme southern Illinois, a great diversity of limestones, shales, clays, siltstones, and sandstones are exposed in places. Figure 1 gives generalized information on the sequence of bedrock formations and figure 2 shows their general distribution. The large-scale *Geologic Map of Illinois* (Weller et al., 1945) shows the distribution of the formations in much greater detail.

No attempt is made in this general report to discuss in detail all the outcropping formations in Illinois. The State has been divided into five districts (fig. 3); for each a brief description is given of the approximate areas of outcrop of the formations of interest for portland cement. In connection with the discussion of outcrop areas, it should be recognized that exposures are not continuous throughout the areas. In some areas exposures are widely scattered; in others they are relatively abundant.

The presence of an outcrop of material that appears to have possibilities for cement does not itself necessarily demonstrate the existence of a deposit of suitable character as a commercial source of cement raw materials. Information regarding the extent of the deposit, its compositional variations, thickness, the thickness of overburden, and other factors must be determined to evaluate fully its possibilities. Table 3 (p. 22) gives location and thickness, as well as chemical analyses, of the samples of various rock formations.

It is not feasible to list all the Geological Survey reports that bear on the distribution, nature, and composition of the rock formations of Illinois, but they include:

Bulletin 17, Portland-Cement Resources of Illinois, 1912.

Bulletin 46, Limestone Resources of Illinois, 1925.

Bulletin 38D, Further Investigations of Illinois Fireclays, 1921.

Bulletin 61, Rock Wool from Illinois Mineral Resources, 1934; contains much information, especially on the less pure limestones of Illinois; out of print but can be consulted in libraries.

Report of Investigations 104, Illinois Surface Clays as Bonding Clays for Molding Sands—An Exploratory Study, 1945.

Report of Investigations 128, Clay and Shale Resources of Extreme Southern Illinois, 1948.

Geologic Map of Illinois, 1945.

Map of the Mineral Industries of Illinois, 1955.

District 1

Outcrops of dolomite are numerous in northern Illinois (fig. 3) but because of their high magnesia content are not of interest for portland cement making. Limestone outcrops are much less common.

FIG. 3.—Index map of districts used in this report.

The formations in district 1 are named below from oldest to youngest. Those formations believed to have possibilities for the manufacture of portland cement are discussed.

CAMBRIAN FORMATIONS

Franconia dolomite

Trempealeau dolomite

ORDOVICIAN FORMATIONS

Oneota dolomite

New Richmond sandstone

Shakopee dolomite

St. Peter sandstone

Platteville formation.—Contains limestone in some places but is mostly dolomitic limestone or dolomite. The amount of magnesia is sufficiently low in some beds, as at Dixon, that they can be used for making portland cement. The Platteville formation crops out principally in northern Lee, Ogle, northeastern Stephenson, and northern Winnebago counties, especially in the vicinity of the Rock River and/or some of its tributaries. It has a thickness of 75 to 125 feet. Analyses are given in table 3, samples S46c, d, and e. A major consideration relating to the use of the formation as a source of cement rock is likely to be that of finding deposits having adequate thickness, satisfactory vertical and lateral uniformity, low magnesia content, and a suitable location with respect to transportation. Convenient sources of clay or shale may be a problem also.

Galena formation.—Crops out widely in the western and central parts of district 1. Throughout most of the district it consists of about 200 feet of dolomite, but in an area northwest of Galena in Jo Daviess County, in extreme northwestern Illinois, the lower 20 to 40 feet of the formation is limestone. Near Central in Grundy County, as much as 40 feet of the formation is limestone, although a few beds contain some dolomite. These beds are only locally exposed in this area, and the extent of the limestone has not been determined.

Maquoketa formation.—Consists principally of shale and impure limestone. It crops out or underlies areas in northwestern Ogle County, southwestern Stephenson County, and Jo Daviess County. It is between about 100 and 200 feet thick. Available information suggests that the magnesia content of the formation is generally in excess of 3 percent. However, careful search might reveal deposits with less magnesia. Samples DS71S and H18.

In the vicinity of Wilmington, Channahon, Minooka, and Oswego in Will, Grundy, and Kendall counties, low outcrops of Kankakee (Silurian) and Maquoketa limestone are present. The analysis of sample NF394 indicates the composition of one of these limestones. Some of the limestones are only a few feet thick; others are interbedded with shale. One outcrop in Grundy County is limestone at the surface but at a shallow depth changes to dolomite. The limited nature of the outcrops does not permit an adequate evaluation of their possibilities for cement.

SILURIAN FORMATION

Niagaran dolomite

PLEISTOCENE DEPOSITS

Glacial till and loess.—Till occurs in all but the northwestern part of district 1 but is believed to be too high in magnesia (analysis DS71D). Loess also is present and commonly is less than 15 feet thick, except near the Mississippi River, where it is much thicker. Some of the loess, as well as the weathered zone on the till, may be suitable.

District 2

District 2* in western Illinois (fig. 3) has cropping out within it many limestone, shale, and clay formations. They are described below from oldest to youngest, and analyses are given in table 3. Some of the limestones are overlain or underlain by shale, and deposits may exist where the materials can be obtained together. Some formations, not believed to be of importance in connection with cement making, are named but not discussed.

*Much of the information regarding the rock formations in district 2 is from Krey (1924), Rubey (1952), Savage and Udden (1921), Wanless (1929), and Workman and Gillette (1956).

ORDOVICIAN FORMATIONS

Cotter (?) dolomite

St. Peter sandstone

Joachim dolomite

Plattin formation.—Crops out for a distance of about 5 miles in the bluffs of the Mississippi River in Calhoun County. It is about 150 feet thick and is mostly limestone and/or dolomitic limestone. Sample R19.

Decorah limestone.—Crops out in the same general area as the Plattin limestone and consists of 5 to 15 feet of brown limestone with thin beds of shale. The brown color is caused by organic material. Sample NF403.

Kimmswick limestone.—Crops out for about 6 miles in the bluffs of the Mississippi River and tributary valleys in western Calhoun County and in a limited area in southwestern Jersey County. It is about 90 feet thick. Much of it is high-calcium limestone. Sample R29.

Maquoketa formation.—Crops out in places in southwestern Jersey County and in western Calhoun County from Batchtown north for about 12 miles. It ranges in thickness from 100 to 200 feet. Shaly dolomite and calcareous mudstone occur in the lower 25 feet of the Maquoketa formation. Above this there is a gradual change to massive and thin-bedded shale. Sample R7 is from the upper part of the formation.

SILURIAN FORMATIONS

Edgewood formation.—Crops out in Calhoun County and southwestern Jersey County. Consists primarily of dolomite and dolomitic limestone, although some parts of the formation are limestone. Reaches a thickness of 50 feet in an area north of Batchtown.

Brassfield formation.—Crops out in Calhoun and southwestern Jersey counties. Varies in thickness from place to place but reaches 30 feet near Hamburg. In some areas the formation is limestone; in others it is dolomitic limestone or dolomite. It contains small chert nodules. Sample R13.

Joliet limestone.—Crops out in Calhoun, southern Pike, and southern Jersey counties. It is about 16 feet thick near Hamburg in northern Calhoun County. A chemical analysis of sample R4, from 16 feet of Joliet limestone and 16 feet of the underlying Brassfield limestone, is given in table 3. Near Grafton the Joliet formation is as much as 60 feet thick but is dolomite.

DEVONIAN FORMATIONS

Wapsipinicon—Cedar Valley formations.—Crop out in limited areas in Rock Island, Calhoun, Pike, and Jersey counties. These beds are used in the manufacture of portland cement near Davenport, Iowa. Near Rock Island they consist of a basal 70-foot unit of limestone, some of it quite pure, a middle 35-foot unit of mostly shaly limestone, and an upper 30-foot unit of dolomite and limestone, shaly in places. The Cedar Valley limestone crops out farther south, principally in Calhoun, western Jersey, and southern Pike counties. It is generally thin, but about 2 miles south of Gilead in Calhoun County there is a narrow zone where it reaches a thickness of about 40 feet. Parts of the formation are sandy and cherty. The Cedar Valley limestone crops out in the vicinity of Grafton but is thin and dolomitic. Samples A, Bu15, DS69, and R14.

MISSISSIPPIAN FORMATIONS

Grassy Creek—Saverton shales.—The dark gray to black Grassy Creek shale and the overlying greenish-gray Saverton shale crop out in the Mississippi and Illinois river bluffs in Pike, Calhoun, Greene, and Jersey counties. Their thickness is variable, but near Rockport and Atlas in Pike County they are about 50 feet thick. These beds are used with the Louisiana limestone in the manufacture of cement near Hannibal, Mo.

Louisiana limestone.—Crops out principally in Calhoun and western Pike counties but is generally less than 10 feet thick, although in northern Calhoun County it reaches 20 to 30 feet thick. It is generally fine-grained relatively pure limestone and is the same formation as that used in the manufacture of portland cement at Hannibal, Mo.

Hannibal group.—Crops out in the Illinois Valley bluffs in Jersey County, in the uplands of Calhoun County, and at intervals in the bluffs of the Mississippi River and its tributary valleys north to the northern part of Pike County. Limited outcrops also occur in the northwestern part of Warren County. This group consists principally of shale and siltstone and ranges between about 30 and 100 feet thick. Sample R5.

North Hill group.—Crops out principally in the Mississippi River bluff area in southern Adams County and the northernmost part of Pike County. It consists mostly of siltstone and limestone. A limestone of varying thickness known as the McCraney limestone occurs at the base of the group. It is similar in character to the Louisiana limestone but is dolomitic in places. It reaches a thickness of about 30 feet near Seehorn, south of Quincy. Sample NF387.

Chouteau limestone.—A formation composed of cherty argillaceous limestone. It crops out extensively in the Illinois and Mississippi river bluffs in Calhoun, western Jersey, and southern Greene counties and reaches a maximum thickness of between 55 and 60 feet. Sample R20.

Fern Glen formation.—Crops out only near Chautauqua and Grafton in Jersey County, where it consists of about 25 feet of thin-bedded greenish shaly cherty limestone.

Burlington limestone.—Crops out at intervals in the bluffs of the Mississippi River or along its tributaries from near Beechville in Calhoun County north to the northern boundary of Henderson County. Through most of this area it forms prominent cliffs in the bluffs of the river. Outcrops of the Burlington limestone also occur in the bluffs and tributaries of Illinois River from near its mouth to northern Pike and Scott counties. In the region between the outcrop areas along the Illinois and Mississippi rivers, outcrops of the Burlington formation occur along some of the major streams. The formation also crops out in northwestern Warren County.

The Burlington formation is generally between 100 and 150 feet thick and consists of more or less cherty light gray or white crystalline limestone. At or near the base is a 20- to 25-foot essentially chert-free zone. This bed is a source of high-calcium limestone in the vicinity of Quincy. Samples R15, B, C15, and SL26–30.

Keokuk limestone.—Crops out in limited areas in southern Calhoun, western Greene and Jersey, northern Adams, and western Hancock counties. The formation is similar to the Burlington, but it is somewhat more finely crystalline and is bluish gray as compared to the light gray or white of the Burlington. A few beds are dolomitic limestone but the formation is largely limestone. Parts of it, especially the upper half, contain shaly layers up to about 2 feet thick. The formation is ordinarily cherty; parts of it are very cherty, especially the basal portion. It ranges between 70 and 100 feet thick. Samples C35b and R200.

Warsaw and Salem formations.—These formations are not easily differentiated in some areas, and, therefore, are discussed together. Much of the Salem is a relatively pure granular limestone which grades downward to Warsaw beds consisting of shaly limestone, limy shale, and shale. The Salem formation is a sandy dolomitic limestone in some places in Hancock County. The formations total 175 to 200 feet thick. Both formations are exposed along the Cap au Gres flexure in southern Calhoun and Jersey counties and are well exposed in the Mississippi River bluffs from Grafton almost to Alton. The Salem formation crops out east of the Illinois River in Jersey, western Greene, and central Scott counties. It crops out locally west of the river in northern Pike and eastern Brown counties and scattered points along the LaMoine River. It also appears in places in western Adams County, in western, northern, and eastern Hancock County, and locally along the Spoon River near Seville in Fulton County. The Warsaw formation is exposed near Warsaw and Nauvoo and elsewhere in Hancock County, especially in the bluffs of the Mississippi River and its tributaries.

Scattered outcrops of the Salem and Warsaw formations occur low in the western bluffs of the Illinois River and some of its tributaries, roughly from Chambersburg in Pike County north to Sheldons Grove in Schuyler County. On the east side of the Illinois River, the Salem-Warsaw begins to crop out low in the bluffs and tributaries about at Oxville in Scott County and is exposed at places northward to a point about 6 miles west of Arenzville in Cass County. Samples NF170b, R122, and C20.

St. Louis limestone.—Commonly 150 to 250 feet thick in the southern part of district 2 but thins to the north as it is truncated by younger beds. It is absent in some places. Much of it is relatively pure limestone, but parts of it are cherty, and impure beds are present in many places. Dolomitic beds are present locally. St. Louis limestone forms the river bluffs at Alton and continues as a conspicuous unit in the bluffs northwestward for several miles. However, the formation rises to the west, so the underlying Salem limestone gradually assumes prominence, and the St. Louis disappears from the bluffs near the western boundary of Madison County. Outcrops occur along some of the valleys tributary to the Mississippi River.

In that part of Calhoun County lying roughly south of Beechville, St. Louis limestone crops out in the bluffs of the Mississippi River and adjacent tributaries. It is also present in the river bluffs in southwestern Jersey County. The St. Louis limestone appears as outcrops low in the western bluffs of the Illinois River and in the valleys of some tributaries from a point about 6 miles north of Chambersburg in Pike County to Sheldons Grove in Schuyler County. The outcrops are relatively small and scattered. Outcrops of similar character appear in the bluffs on the east side of the river and in its tributaries about at Oxville in Scott County and continue north to a point about 6 miles west of Arenzville in Cass County. Other scattered outcrops occur along the LaMoine River and adjacent areas in Schuyler, McDonough, and Hancock counties and along the Spoon River near Seville in Fulton County. It occurs in a small area in western Hancock County. Samples R33, C, and R143.

Ste. Genevieve limestone.—This formation is exposed only in the vicinity of Alton, where it is generally less than 50 feet thick. It is largely pure oolitic limestone, but some beds are sandy.

PENNSYLVANIAN FORMATIONS

Pennsylvanian rocks underlie the uplands in many areas in district 2. Because the older rock formations were subjected to erosion before the Pennsylvanian strata were deposited, the latter rest directly on many of the older formations. The Pennsylvanian rocks consist of shale, sandstone, siltstone, clay, limestone, and coal. The limestones are rarely more than 20 feet thick and most of them are less than 10 feet thick. They range from relatively pure to impure. Many of them are the "caprocks" of coal. The clays occur principally below the No. 2 coal of western Illinois although other coals also are underlain by clay. The clays are generally less than 20 feet thick and vary from plastic refractory clays to calcareous clays. Some of the shales are clayey, others relatively silty or sandy. One of the thicker shales occurs in the vicinity of Gilchrist in Mercer County and varies from 20 to more than 100 feet thick. Samples R34 and C46 are limestones; R11 and L7b are shales; MD5 and D are clays.

PLEISTOCENE DEPOSITS

Glacial till.—This clayey material is present in the upland areas throughout district 2, but in general the magnesia content is believed to be too high for cement making. However, the upper few feet of some deposits has been leached of its carbonates and thus may have a reduced magnesia content.

Loess.—This material mantles the counties and rests on the glacial till or on the bedrock where the till is absent. It is brown silt except for the upper few feet, which is weathered and clayey. Commonly it is 50 feet or more thick in the bluffs of the major river valleys, but it thins back from the bluffs. Except for that in the weathered zone, the loess is generally too high in magnesia to be used in cement.

Alluvium.—Gravel, sand, silt, and some clayey silt or silty clay are present in the alluvium of the major rivers. The magnesia content is generally moderately high in these deposits.

District 3

District 3* in southwestern Illinois (fig. 3) contains many rock outcrops including limestone, shale, and clay. These are described below from oldest to youngest, and analyses are given in table 3. In the case of limestones overlain or underlain by shale or clay formations, there is a possibility that deposits may exist from which both materials can be obtained.

In the vicinity of Valmeyer in Monroe County, an upfold in the bedrock strata causes the appearance in a limited area of several formations that are not exposed elsewhere in the district.

ORDOVICIAN FORMATIONS

Kimmswick limestone.—Crops out in a limited area near Valmeyer, Monroe County. About 100 feet thick. Most of the formation is a limestone of high purity. The deposit is being commercially developed.

Maquoketa shale.—Exposed in a roughly 1-square-mile area east of Valmeyer in the bluffs and tributaries of the Mississippi Valley. About 100 feet thick. The lower part of the formation is more or less dolomitic. Sample S22.

MISSISSIPPIAN FORMATIONS

Fern Glen formation.—Crops out only in a limited area in the bluffs and tributaries of the Mississippi River near Valmeyer, Monroe County. Consists of red and green shaly limestone and interbedded shale. The upper part of the formation is cherty. About 30 feet thick.

Burlington-Keokuk limestone. — Crops out in places in an area about three-quarters of a mile wide extending from Valmeyer southeast for about 4 miles and in a tract of roughly similar size extending south and a little east from a point 2½ miles southeast of Columbia. A very cherty limestone 150 feet or more thick. Sample NF90.

Warsaw formation.—Occurs in a zone about three-quarters of a mile wide extending southeast from Valmeyer for about 4½ miles, in valleys of the Mississippi River bluff southwest of Renault, Monroe County, and in a narrow zone surrounding the Burlington-Keokuk limestone area south of Columbia. This zone extends southward to Waterloo. In St. Clair County upper Warsaw strata underlie a small area in Cement Hollow in the NE¼ sec. 33, T. 1 N., R. 10 W. A 6- to 8-foot bed of dolomitic limestone was the source of stone used in making "natural" cement about 1865 (Worthen, 1866, p. 310). The lower half of the formation is shale and calcareous shale with thin strata of limestone. The upper part of the formation is shaly impure limestone which is cherty in places. The formation is about 60 feet thick. Sample S21.

Salem limestone.—Crops out conspicuously at many places in the bluffs and tributary valleys of the Mississippi River in western Monroe County from Fountain south to the southern boundary of the county. It also underlies a sizable upland area east of Valmeyer with an elongate tongue extending southeast to a point about 1 mile east of Maeystown. An elongate oval-shaped band extending roughly from the vicinity of Columbia in St. Clair County to south of Waterloo in Monroe County is also underlain by the Salem limestone. Scattered areas underlain by the limestone occur between Columbia and the Mississippi River bluffs; the outcrops terminate in sec. 33, T. 1 N., R. 10 W., a little over a mile north of the boundary of Monroe County. Much of the Salem limestone is of high purity. Some parts of the formation are oolitic; parts of the formation contain nodules of chert. Thickness from 100 to 300 feet. Samples NF167A, NF332A, NF332E, and L70.

St. Louis limestone.—Exposed in the bluffs and tributary valleys of the Missis-

*Much of the information regarding the rock formations of district 3 is from Weller and Weller (1939).

sippi River from near Stolle in St. Clair County, southeast of Cahokia, more or less continuously to 1 mile southeast of Prairie du Rocher in Randolph County, except for an area around Valmeyer. It underlies much of the western half of Monroe County and crops out at many places. The character of the formation is variable; upper and lower portions are likely to be somewhat cherty, the middle portion less so. Beds of dolomitic limestone occur in the middle portion. Thickness about 200 feet. Samples NF163D, NF163P, NF162K, and NF331F.

Ste. Genevieve limestone.—Beginning at a point in the Mississippi River bluffs about 1 mile north of the boundary of Monroe County, this limestone crops out in places in the river bluffs southward for about 6 miles and also underlies an elongate area roughly one-half to 2 miles wide extending southeast to Burksville in Monroe County. It also is present in a narrow zone about one-eighth of a mile wide extending roughly from a point about a mile west of Waterloo north to Columbia and in a generally elongate north-south area extending northward for about 4 miles from Rodemich, which is roughly 3 miles west and 1 mile south of Millstadt in St. Clair County. It also occurs near Prairie du Rocher in Randolph County.

Much of the Ste. Genevieve is oolitic limestone. The lower part of the formation has a few chert beds. Thickness about 100 feet. Samples L66 and NF330A.

Chester series.—Consists of a sequence of formations from the Aux Vases sandstone at the base to the Kinkaid limestone at the top of the series. One or more of the Chester formations underlie a small area in southwestern St. Clair County, most of eastern Monroe County, the uplands of northwestern Randolph County, and in a band roughly 4 to 6 miles wide in and adjacent to the Mississippi River bluffs from Chester southeast to the southern boundary of district 3. The formations are discussed briefly below and some of the better outcrop areas noted. Details of distribution are discussed by Weller and Weller (1939).

Aux Vases sandstone

Renault formation.—A variable formation consisting of sandstone, shale, and limestone. Thickness commonly 40 feet or more. The formation is well exposed in valleys northeast of Renault.

Yankeetown chert

Paint Creek formation.—Shale, clay, and limestone. The limestone is locally as much as 50 feet thick. Thickness of formation 50 to 100 feet. Exposed southeast of Modoc, Randolph County.

Ruma formation. — Principally shale with some sandstone. Thickness 60 to 70 feet. Good exposures in the vicinity of Ruma.

Okaw limestone.—Underlies and crops out in places in a part of eastern Monroe County in the general vicinity of Hecker, underlies much of western Randolph County, and occurs in the Mississippi River bluff from 2 miles south of Modoc almost to Mary's River. Consists of the following units in ascending order: a basal dark limestone about 20 feet thick, 50 to 70 feet of shale containing limestone lenses up to 10 feet thick, about 50 to 60 feet of limestone including some oolite, 20 to 40 feet of shale, and (at the top) 40 to 50 feet of limestone with interbedded shales up to 5 feet thick. Thickness totals about 200 feet. Samples L67, W254, S1, K23, and K8 are limestone. Sample S3 is shale.

Baldwin formation.—Shale, sandy shale, sandstone, and a few feet of limestone. Thickness 60 to 75 feet. Crops out near Chester.

Menard formation. — Limestone and shale interbedded. Good exposures in the Mississippi River bluff between Chester in Randolph County and the mouth of Mary's River. Thickness 70 to 85 feet. Samples S7 and K13B are limestone. Samples S11 and S14 are shale.

Palestine sandstone

Clore formation.—Shale, limestone, and sandstone 50 to 60 feet thick. Crops out southeast of Chester on Mary's River and south of Chester in the Mississippi River bluff. Sample S9.

Degonia sandstone

Kinkaid limestone. — Limestone with some shale beds a few feet thick. Cherty beds present in places, especially in the upper part of the limestone. Maximum thickness about 60 feet. Good exposures on Kinkaid Creek about 6 miles east and a little north of Rockwood, Randolph County. Also crops out in the Mississippi River bluff from Mary's River south of Chester almost to Grimsby in western Jackson County.

PENNSYLVANIAN FORMATIONS

Pennsylvanian formations underlie and locally crop out in much of the eastern portion of district 3, especially western St. Clair, central Randolph, and western Jackson counties. Consist of shale and sandstone with coal and thin limestones in some places. Limestones occur in the bluff of the Mississippi River east of East St. Louis and reach a thickness not known to exceed 10 feet and usually less. The possibilities of the limestone caprock of coal No. 6 are mentioned in district 5. Pennsylvanian sandstone crops out in the Mississippi bluffs near Grimsby in Jackson County, along Big Muddy River near Murphysboro, and at other places. Samples NF80 and NF84 are limestone.

PLEISTOCENE DEPOSITS

Glacial till.—Rests on the bedrock at many places. Much of it may be too dolomitic to be significant as a cement raw material. Thickness 25 to 50 feet.

Loess.—Rests on the glacial till or directly on the bedrock where the till is absent. Thickness 50 feet or more in the Mississippi River bluffs but thins away from the valley. Samples S4 and L9.

Alluvium.—Probably mostly silt, clayey silt, or sand along major streams.

District 4

District 4* in extreme southern Illinois (fig. 3) has within it many different limestone formations and a number of shale formations. These are discussed below from oldest to youngest. Sandstone and chert formations are listed but not described because they generally are not used for cement making. Chemical analyses are given in table 3.

The geology of southern Illinois is locally quite complicated, especially in Hardin County, where faulting is complex. In that area an eroded dome in the bedrock, known as Hicks Dome, centering in sec. 30, T. 11 S., R. 8 E., about 5 miles north of Rosiclare, adds to the diversity of the geology and rock exposures. Igneous rock occurs in a few places on and near the dome. Because of the varied geology of the district, the distribution of the rock formations can be indicated only in a general way.

ORDOVICIAN FORMATIONS

Kimmswick limestone.—Crops out in a small area in the Mississippi River bluff about 1 mile south of Thebes, Alexander County. About 100 feet thick. Much of the limestone is high purity. Sample E.

Thebes sandstone

SILURIAN FORMATIONS

Orchard Creek shale.—Crops out in the vicinity of Thebes and Gale, Alexander County. It is silty and contains thin limestone layers. Thickness about 20 feet.

Girardeau limestone.—Limestone in thin layers separated by thin shale partings. Contains scattered nodules of chert. Crops out in bluffs of the Mississippi River and tributary valleys south of Thebes, Alexander County, and along Harrison Creek east of Reynoldsville, Union County. Thickness about 30 feet. Sample L37.

Edgewood formation.—Crops out near Gale and Thebes, Alexander County. Principally silty limestone. Thickness 10 feet or less.

Sexton Creek limestone.—Crops out in a bluff of the Mississippi River and tributary valleys east and southeast of McClure, Union County, and near Gale and Thebes in Alexander County. A cherty limestone as much as 40 feet thick.

Bainbridge limestone.—Crops out in the Mississippi River bluff east of McClure,

*Much of the information regarding the rock formations of district 4 is from Butts (1925), Lamar (1925), Weller (1940), Weller and Ekblaw (1940), Weller and Krey (1939), Weller et al. (1920), and Weller, et al. (1952).

Union County, along valleys east of Reynoldsville in Union County, and east of Gale and Thebes in Alexander County. The lower part of the formation, to a thickness of about 25 feet, is relatively pure red and green limestone. Sample NF449. The upper part of the formation is mostly red and green shaly limestone and calcareous shale and is about 100 feet thick.

DEVONIAN FORMATIONS

Bailey limestone.—Crops out as prominent cliffs in the Mississippi River bluffs east of McClure in Alexander County and at Reynoldsville and Aldridge in Union County; also exposed in Alexander County southeast of Thebes. It is generally very cherty; the upper part is largely chert in places. It is about 400 feet thick. Samples NF93, 94.

Backbone limestone.—Crops out in a small area at Grand Tower in Jackson County, in the Mississippi River bluff east of Grand Tower, along Hutchins Creek, and in the uplands to the west of the creek in an area north of Wolf Lake in Union County. The limestone is gray-white to white and much of it is pure. The formation has a maximum thickness of about 80 feet. Samples L53 and NF444.

Clear Creek chert.—Crops out widely in western Union and northern Alexander counties. Consists principally of chert. The formation includes cherty siliceous limestone north of Jonesboro in Union County. The formation is 300 or more feet thick.

Dutch Creek sandstone

Grand Tower, Lingle, and Alto limestones.—These closely related Devonian limestones crop out in a limited area near Grand Tower in Jackson County and in a narrow belt extending south from near Mountain Glen to near Ullin in Pulaski County. Largely relatively pure limestone, but the basal part is sandy and the upper part is shaly. Shale predominates south of Jonesboro. Thickness varies from 400 feet north to 50 feet south. Part of this sequence is exposed in the central part of Hicks Dome in Hardin County, where it is limestone. Sample S5 is Grand Tower limestone.

DEVONIAN AND MISSISSIPPIAN FORMATION

New Albany shale.—The New Albany shale, also sometimes called the Chattanooga or Mountain Glen shale, underlies an O-shaped band around Hicks Dome about 8 miles north of Rosiclare in Hardin County. The shale is dark gray or black and may be as thick as 400 feet at Hicks Dome, although outcrops are generally small. The shale also crops out in Alexander, Pulaski, and Union counties, where it is generally less than 50 feet thick. It underlies a narrow north-south zone roughly between a point a few miles west of Ullin in Pulaski County to Mountain Glen in Union County. Sample 1.

MISSISSIPPIAN FORMATIONS

Springville shale.—Crops out in about the same area as the Mountain Glen shale. It is about 60 feet thick and consists of greenish shale, the upper part of which is siliceous—locally highly siliceous. A similar ten-foot shale bed overlies the New Albany shale in Hardin County. Samples LM14 and W286.

Burlington-Keokuk (Osage) rocks.—Crop out on Hicks Dome in Hardin County, in a small area southwest of Equality in Gallatin County, and in a belt extending from near Mountain Glen to Ullin in Union, Alexander, and Pulaski counties. The rocks in the eastern area are highly siliceous limestone that weather to chert and are as much as 550 feet thick. The rocks in the western area consist principally of limestone with chert beds; in places they are largely chert. The formation is as thick as 300 feet.

Warsaw and Salem limestones.—Beginning at a point midway between Ullin and Wetaug in Pulaski County, these limestones underlie an elongate zone extending north and west to near Mountain Glen. The zone is about one-half to 2 miles wide in Pulaski County and the adjacent part of Union County, but to the north it becomes narrower; its exact width has not been determined. The lower part of the Warsaw-Salem is a dark limestone that contains a small amount of chert in some places. It is exposed in the hills north of Ullin and at other points. The upper part of the formation crops out east and southeast of Mill Creek in Union County and north to near Jonesboro. It is a light-gray granular limestone of high purity. The thickness of the Salem-Warsaw in Pulaski and Union counties is probably about 400 feet. Samples W285, L10, L1, and NF443.

Warsaw-Salem beds underlie an O-shaped band, about half a mile wide, around Hicks Dome in Hardin County. The formation is estimated to be about 250 feet thick. The lower three-quarters is dark-gray limestone, locally cherty; the upper quarter is light-gray granular limestone, some of which is quite pure.

A relatively small outcrop of Warsaw-Salem limestone occurs in Walker Hill at Grand Tower in Jackson County. Some of the limestone is cherty.

St. Louis limestone.—Beginning at a point about 2 miles south of Alto Pass, Union County, St. Louis limestone underlies a southeast-trending zone, which is half a mile wide initially, broadens to about a mile at Jonesboro in Union County, and then expands to about 3 miles and continues so to beyond Dongola in Union County for about 3½ miles to the flats of the Cache River in Pulaski County. A small outcrop is reported southwest of Perks, Pulaski County, in the uplands south of the Cache River flats. The thickness of the limestone ranges roughly between 200 and 350 feet. Its composition varies from moderately impure to relatively pure limestone. Chert occurs in parts of the formation.

The St. Louis limestone in Hardin County underlies an O-shaped band roughly half a mile to 1 mile wide around Hicks Dome north of Rosiclare. An elongate tract, one-quarter to three-quarters of a mile wide, underlain by the St. Louis limestone, extends along the south side of Hogthief Creek from Pankey's store, 4 miles north of Elizabethtown, northeast for about 3 miles. Another area of St. Louis limestone extends along the Ohio River roughly from Cave in Rock west to within 1½ miles of Elizabethtown. The maximum width of the area is about 2 miles. The character of the St. Louis limestone in Hardin County is similar to that in Union County, but some of it is very dark gray or black. It is believed to be 500 feet thick. Good outcrops occur in the Ohio River bluffs.

Two small areas underlain by St. Louis limestone occur in Saline County at the base of Cave Hill, roughly 4 miles southwest of Equality in Gallatin County. A small area of St. Louis limestone occurs in Walker Hill near Grand Tower, Jackson County.

Ste. Genevieve formation.—This formation consists of the Fredonia limestone member, about 175 to 200 feet thick (the thickest unit), above which lies the Rosiclare sandstone. This in turn is overlain by the Levias limestone, which is similar to parts of the Fredonia and reaches a maximum thickness of about 50 feet in the eastern part of southern Illinois. In the western part, the upper Ste. Genevieve consists of oolitic limestone and much shale and sandstone. These members have not been mapped separately in much of southern Illinois, so they are discussed together, although the data relate largely to the Fredonia limestone.

The principal zone of outcrop of the Ste. Genevieve formation in Union County begins roughly at Mountain Glen and extends to the southeast in a band that reaches a width of 2 or 3 miles at Anna and continues to the northern edge of the Cache River flats near Perks in Pulaski County. From there it extends to the east, gradually decreasing in width to Belknap in Johnson County. In the uplands bordering the southern edge of the Cache River flats, relatively small areas of Ste. Genevieve limestone occur south and southeast of Perks in Pulaski County and in Massac County north of Boaz and northeast of Grinnell. Samples D2, U66, and W304.

Small outcrops believed to be Ste. Genevieve limestone occur in or near the Ohio River bluffs at Hamletsburg and Bay City in Pope County.

The Ste. Genevieve limestone in Hardin County underlies a roughly U-shaped area around Hicks Dome about 8 miles north of Rosiclare with the open end of the U to the southeast. At each end of the U the area of the Ste. Genevieve is several miles wide, but towards the curved part of the U the area narrows to about 1 mile. The southwest side of the U extends to a little east of Shetlerville, where the Ste. Genevieve is exposed in the Ohio River bluffs for a short distance. Farther east the limestone crops out in the Ohio River bluff east of Cave in Rock for about a mile. From there, the area underlain by the formation forms an arch about 2 miles wide, extending northwest for about 4 miles, from there southwest to the river bluffs about 1½ miles east of Elizabethtown, and continuing to Rosiclare. Samples NF177B and NF177C.

Small outcrops of Ste. Genevieve limestone occur in the northern slopes of Wildcat Hills and Cave Hill south and southwest of Equality in Gallatin County and in Walker Hill east of Grand Tower in Jackson County.

The character of the Ste. Genevieve limestone varies from relatively impure to pure, although the purer rock is believed to be more common. Much of the formation is oolitic; some of it is cherty.

Chester series.—This series of rocks is composed of limestone or limestone and shale formations alternating with sandstone or sandstone and shale formations. The distribution pattern of the formations is too complex to discuss in detail. However, considering the Chester series as a whole, it underlies an area a few miles wide beginning in the Mississippi River bluffs east of Grand Tower in southwestern Jackson County and extends southeastward to Vienna, where it underlies an area about 10 miles wide about equally divided north and south of Vienna. From there the band of Chester rocks proceeds with some interruptions east to central Pope County and into the northwestern corner of Hardin County, where the outcrop band narrows to about 3 miles. From the corner of Hardin County the band makes an arc, broadening somewhat and interrupted locally, to the southeastern corner of the county at the large bend in the Ohio River. Other relatively small areas underlain by Chester rocks are present in Wildcat and Cave Hills south and southwest of Equality in Saline and Gallatin counties, about 3 miles southeast of Rudiment in Saline County and an adjoining part of Pope County, at places in the uplands of southern Pope County, at the southern end of Fountain Bluff north of Grand Tower in Jackson County, and at a few other places.

The Chester rocks are discussed below, beginning with the oldest formation.

Renault formation.—Alternating limestone and shale strata, the limestone predominating. Well exposed near Belknap in Johnson County. Thickness 60 feet or less to about 90 feet. Samples D16, D17, L11, and L16.

Bethel sandstone

Paint Creek formation.—Shale or shale and sandstone; in places contains limestone in its upper part. Thickness 40 feet or less to 60 feet. Sample L20.

Cypress sandstone

Golconda formation.—Limestone and shale. Limestone is most common in the upper and lower parts of the formation, shale in the middle part. Thickness 110 to 180 feet. Samples W308, W319, Bu20, Bu23, and probably Bu22.

Hardinsburg sandstone

Glen Dean formation.—Limestone at places in upper or lower part of formation. Middle part usually shale. Thickness 30 to 90 feet.

Tar Springs sandstone

Vienna formation.—Limestone and shale. Thickness about 20 feet. Sample L100.

Waltersburg sandstone

Menard formation. — Limestone and shale interbedded, the former predominating. Thickness 70 to 120 feet. Samples T1, T2, T5, and probably D48.

Palestine sandstone

Clore formation.—Shale and sandstone with thin limestone beds near top and bottom. Thickness 50 to 100 feet.

Degonia formation.—Largely sandstone in west; includes much shale with limestone beds up to 5 feet thick in the east. Thickness 30 to 140 feet.

Kinkaid limestone.—Principally limestone with lesser amounts of shale. Thickness up to 200 feet but usually 50 to 150 feet. Samples K29, CH1–2, W1–6.

PENNSYLVANIAN FORMATIONS

Pennsylvanian rocks occur chiefly in Gallatin, northeastern Hardin, northern Pope, northern Johnson, northeastern Union, and Jackson counties. Principally sandstone, shaly sandstone, sandy shale, shale, conglomerate; in places, relatively thin coals and, rarely, thin limestones.

POST-PENNSYLVANIAN ROCKS

Small outcrops of igneous rocks are found in western Hardin and eastern Pope counties. Most or all of the outcrops are believed to be too small to be important as a source of cement raw materials.

CRETACEOUS AND TERTIARY FORMATIONS

The Cretaceous and Tertiary rocks consist of sand, silt, clay, and gravel. They are exposed in places in southern Pope, central and southern Massac, and north-central Pulaski counties, at the southern end of the uplands of Alexander County and in the vicinity of Fayville and Unity, and at a few places in Union County. Kaolin clay exists near Mountain Glen in Union County. Samples AK and B4.

The Porters Creek formation, from which clay for fuller's earth has been produced, is well developed near Olmsted in Pulaski County and Unity in Alexander County. It reaches a thickness of about 125 feet. Sample FE116 is fuller's earth; sample La3 lies below the fuller's earth.

PLEISTOCENE DEPOSITS

Residual clay.—At various places in district 4 the limestone deposits are overlain by a residuum of red clay from the leaching of the limestones. The thickness of the clay varies greatly but may not average more than 10 feet. Sample B21.

Terrace clays and silts.—Silty clay and silt occur in terraces in the flood plains of many of the major streams.

Loess.—A brown clayey silt reaching a thickness of 75 feet or more in the Mississippi River bluffs and 20 feet or more along the Ohio River. Its thickness decreases inland from the rivers. It may rest on any of the previously described formations. Samples DS4 and L10.

Alluvium.—Clay, silt, sand, and gravel in the flood plains of streams.

District 5

The bedrock of district 5 (fig. 3) is all of "Coal Measures" or Pennsylvanian age except in limited areas around LaSalle, where older rocks, chiefly sandstone and dolomite, are exposed. The Pennsylvanian rocks consist principally of sandstone and shale with lesser amounts of limestone and coal. Many of the limestones are less than 10 feet thick, but in places the limestone is as much as 30 feet thick.

Quarries producing agricultural limestone or road rock are located in many outcrops of the thicker Pennsylvanian limestones. Usually the overburden is glacial clay (till), but in places shale is also present above the limestone. Most of the limestones are underlain by shale.

Many coals in Illinois have a caprock of limestone either directly on or only a few feet above the coal. In southern and western Illinois, some of these limestones are well exposed in coal strip mines.

It is impossible to discuss in this general report all the Pennsylvanian limestones and their areas of outcrop. However, a number of the thicker or otherwise-important limestones are mentioned briefly below. Chemical analyses are given in table 3.

ROCKS OLDER THAN THE PENNSYLVANIAN STRATA

These rocks are principally sandstone, dolomite, or dolomitic limestone, include the Shakopee dolomite, the St. Peter sandstone, and the Galena-Platteville dolomite, and occur in LaSalle County. However, the latter formation locally contains limestone strata, as near Lowell, where there are two limestone units, 14 and 20 feet thick, containing 52 percent lime (CaO) and less than 3 percent magnesia (MgO).

PENNSYLVANIAN ROCKS

Following are brief notes on some of the major outcropping Pennsylvanian limestones that are not caprocks of coals and are being worked commercially.

LaSalle limestone.—Crops out at LaSalle, west of LaSalle, and at Oglesby in LaSalle County. The limestone is used extensively by three large plants to make portland cement. Thickness about 20 to 25 feet. The limestone contains interbedded shale. Samples C2ad, C3abd, and Dx17B.

Pontiac limestone.—Crops out in the vicinity of Pontiac, McDowell, and Ocoya in Livingston County. Thickness 10 to almost 25 feet. Samples P3 and P8.

Livingston limestone.—Exposed at Fairmount in Vermilion County, in the vicinity of Marshall and Casey in Clark County, and east of Charleston in Coles County. Usually consists of a lower limestone stratum 10 to 15 feet thick separated by 3 to 15 inches of shale from an upper limestone stratum up to about 8 feet thick. The shale apparently is absent in places, and the two limestone strata are in contact. At other places the upper limestone and shale have been removed by erosion. Samples S51ac, S9, and S3.

Millersville limestone. — Exposed in southern Christian County north of Nokomis and near Ramsey in northwestern Fayette County. Consists of 10 to 25 feet or more of limestone; in most places there is a shaly parting up to 18 inches thick in the upper portion.

Lonsdale limestone. — Exposed near Princeville, Peoria, Trivoli, and Cramer in Peoria County, east of Petersburg in Menard County, and near Lincoln in Logan County. The limestone ranges from about 10 feet to about 25 feet thick. Its composition varies. Samples Bu8, DS55, NF455.

Shoal Creek limestone.—Exposed near Radom in Washington County, Carlyle in Clinton County, Litchfield in Montgomery County, Sorento in Bond County, and east of Carlinville in Macoupin County. The limestone is roughly between 6 and 20 feet thick. Where the limestone is thickest it contains a shale parting. Sample L425.

Omega limestone.—Exposed south and southeast of Iola in Clay County, near Gilmore in Effingham County, and near Tower Hill in Shelby County. Thickness ranges between 5 and 15 feet; purity also varies. Usually the thicker limestone is more or less impure. Most of the deposits near Tower Hill are believed to be relatively impure; some reach a thickness of 25 feet.

CAPROCKS OF COALS

Coal No. 6 is produced by strip mining in Saline, Williamson, Randolph, Perry, Jackson, and St. Clair counties and coal No. 5 in Williamson, Saline, and southern Gallatin counties. The caprock of No. 6 coal varies from 0 to about 25 feet thick, and where the caprock is well developed, a common thickness is 10 to 15 feet. The caprock limestone of No. 5 coal is usually less than 5 feet thick and is absent at many places. Samples NF79, NF69, NF73, and NF76.

In Fulton, Peoria, and Knox counties in western Illinois, coals No. 5 and No. 6 are also stripped and have limestone caprocks that rarely exceed 5 feet and are generally less thick, especially the limestone above No. 5 coal. Shale is interbedded with the limestone in places. Sample NF245.

SHALES

District 5 contains many shale formations, some of which are used for making structural clay products. The analyses in table 3 show the locations and compositions of a number of these shales. Samples W79, R215, K2, K3, K4, K6, K7, and K14.

PLEISTOCENE DEPOSITS

Glacial till.—A pebbly or stony clay (glacial till) occurs in deposits from a few feet to over 100 feet thick at many places in district 5. It lies above the bedrock. It usually contains more than 3 percent magnesia, although locally the weathered and leached parts of the till may contain less magnesia. Usually such clays are not more than 5 feet thick. Samples B18 and DS101.

Loess.—Loess or loess-like silt overlies the till in many parts of district 5. It is thickest in those areas near the Illinois and Mississippi rivers but thins rapidly inland from the rivers and is only 2 to 10 feet thick over much of the district. Sample R216.

Alluvium.—Gravel, sand, silt, and silty clay in the flood plains of streams.

TABLE 3.—SOURCES AND CHEM-

Sample No.	County	Near	T.	R.	Sec.	¼	¼	Thickness ft.	Formation	Reference*
				DISTRICT 1						
				Limestones						
S46c	Lee	Dixon	22N	9E	27			5	Platteville	a
S46d	Lee	Dixon	22N	9E	27			10	Platteville	a
S46e	Lee	Dixon	22N	9E	27			9	Platteville	a
NF394	Will	Wilmington	33N	10E	31	NE	NE	12	Kankakee	c
				Clays and Shales						
H18	Whiteside	Sterling							Maquoketa	d
DS71S	Jo Daviess	Rice	27N	1E	14	NW	SE	40	Maquoketa	e
DS71D	Lee	Dixon	22N	9E	27	SE	NW	30	Glacial till	f
				DISTRICT 2						
				Limestones						
R19	Calhoun	Batchtown	12S	2W	19	NE	SE	50	Lower Plattin	h
NF403	Calhoun	Batchtown	12S	2W	6	SE	NE	7	Decorah	i
R29	Calhoun	Batchtown	12S	2W	17	NW	SE	37	Kimmswick	h
R13	Jersey	Nutwood	8N	13W	29	SE	NE	8	Brassfield	h
R4	Calhoun	Hamburg	9S	3W	35	NW	SE	16	Joliet and Brassfield	h
A†	Rock Island	Rock Island							Probably Wapsipinicon	j
Bu15	Rock Island	Milan	17N	2W	25			20	Probably Cedar Valley	a
DS69	Rock Island	Milan	17N	2W	25	SE	NW	14	Probably Cedar Valley	e
R14	Jersey	Nutwood	8N	13W	29	NE	NE	13	Cedar Valley	h
NF387	Adams	Seehorn	3S	7W	31	SW	NE	29	McCraney	c
R20	Calhoun	Hardin	10S	2W	27	E½		15	Chouteau	h
R15	Calhoun	Hardin	10S	2W	28	SE	SE	70	Burlington	h
B	Adams	Quincy							Burlington	j
C15	Adams	Quincy	2S	9W	11			30?	Burlington	a
SL26–30	Henderson	Gladstone	10N	5W	11	NW	SE	16	Burlington	c
C35b	Schuyler	Camden	2N	3W	17	NW		11	Keokuk	a
R200	Brown	Gilbirds	1S	2W	31	NW	NW	12	Keokuk	c
NF170b	Madison	Alton	5N	10W	4	SE		22	Salem	c
R122	Scott	Winchester	14N	13W	27	NE	SE	26	Salem	c
C20	Brown	Versailles	2S	3W	26	NW		13	Salem	a
R33	Calhoun	Golden Eagle	14S	1W	6	NE	SW	39	St. Louis	f
C	Madison	Alton							St. Louis	j
R143	Brown	Cooperstown	1S	1W	20	NW	NW	13	St. Louis	c
R34	Calhoun	Brussels	13S	2W	14	SW	SW	8	Pennsylvanian	h
C46	Schuyler	Browning	2N	1E	32	NW	SW	15	Pennsylvanian	a
				Clays and Shales						
R7	Calhoun	Gilead	11S	2W	17	NE	SW	16	Maquoketa	h
R5	Calhoun	Hamburg	9S	3W	36	SW	NE	40	Hannibal	h
R11	Calhoun	Golden Eagle	14S	2W	1	NE	SE	30	Pennsylvanian	h
L7b	Schuyler	Frederick						10	Pennsylvanian	b
MD5	Madison	Alton	6N	10W	35	SE		4	Pennsylvanian	c
D	Calhoun	Belleview	8S	3W	6	NE	SW		Pennsylvanian	k

*See notes at end of table.
†Samples that do not have numbers in their source publications have been assigned capital letters.
**R_2O_3.
‡Includes both Fe_2O_3 and FeO.

ical Analyses of Samples

SiO_2	Al_2O_3	Al_2O_3 and Fe_2O_3	Fe_2O_3	MgO	CaO	Loss on ignition	Sample No.
			DISTRICT 1				
			Limestones				
7.56		3.54		.60	48.48	40.54	S46c
5.10		2.58		4.58	45.84	41.94	S46d
4.78		4.44		2.40	47.04	41.92	S46e
4.24	1.21		.71	4.83	47.20	41.77	NF394
			Clays and Shales				
39.91	16.43		4.80	5.08	7.57	21.02	H18
48.93	10.43		3.68	6.80	10.85	16.71	DS71S
45.91	13.62		4.03	6.60	12.06	16.96	DS71D
			DISTRICT 2				
			Limestones				
2.19	.72		.46	5.35	48.41	43.01	R19
9.80	1.83		.41	1.67	45.24	41.04	NF403
.74	.28		.62	.42	55.52	42.67	R29
2.10	.48		.32	.60	53.93	42.70	R13
2.71	.38		.62	.42	53.36	41.82	R4
1.66		1.16		.58	54.18	43.38	A
6.98		4.32		2.64	45.98	40.00	Bu15
13.42	5.13		2.41	3.75	39.30	36.06	DS69
9.92	.54		.46	.50	49.57	39.23	R14
				5.53	46.62	42.70	NF387
14.90	2.02		1.24	1.31	44.23	36.28	R20
2.64	.14		.46	.73	53.79	42.17	R15
.21	.04		.10	.61	55.17		B
19.78		1.94		.84	43.42	35.10	C15
2.79	.32		.22	.64	53.90	42.34	SL26–30
15.80		5.88		6.84	36.00	36.92	C35b
9.82	.67		.77	.51	48.84	39.18	R200
3.79	.42		.32	2.93	50.99	42.28	NF170b
4.07	1.42		1.65	7.95	42.30	42.42	R122
16.90		3.06		.54	43.88	35.98	C20
3.23	.44		.62	.59	53.21	41.98	R33
1.00			Tr.	.65	54.81		C
10.34	.43		1.30	.48	48.50	38.12	R143
1.53	.22		.62	.63	54.29	42.80	R34
3.10		2.14		.44	53.12	42.22	C46
			Clays and Shales				
56.69	23.31		6.05	2.81	1.80	7.92	R7
69.20	15.38		4.18	2.50	1.35	5.90	R5
58.04	24.40		6.66	2.04	1.05	7.61	R11
73.66	16.37		2.06	2.10	.63	4.85	L7b
56.92	26.80		2.51	.51	.17	10.41	MD5
57.24	30.74		1.74	.30	Tr.	10.03	D

Table 3.—

Sample No.	County	Near	T.	R.	Sec.	¼	¼	Thickness ft.	Formation	Reference*
				DISTRICT 3						
				Limestones						
NF90	Monroe	Valmeyer	2S	12W	35	SW		35	Burlington-Keokuk	f
S21	Monroe	Fults	4S	10W	36	SE	SE	95	Warsaw-Salem	c
NF167A	Monroe	Columbia	1S	10W	14	SW	SW	35	Salem	c
NF332A	Monroe	Prairie du Rocher	5S	9W				44	Salem	c
NF332E	Monroe	Prairie du Rocher	5S	9W				28	Salem	c
L70	Monroe	Valmeyer	3S	11W	15	NW	SE		Salem	j
NF163D	St. Clair	Dupo	1N	10W				21	St. Louis	c
NF163P	St. Clair	Dupo	1N	10W				25	St. Louis	c
NF162K	St. Clair	Dupo	1N	10W				14	St. Louis	c
NF331F	Randolph	Prairie du Rocher	5S	9W				16	St. Louis	c
L66	Monroe	Columbia	1S	10W	17	SE	SW	35±	Ste. Genevieve	f
NF330A	Randolph	Prairie du Rocher	5S	9W				14	Ste. Genevieve	c
L67	Monroe	Red Bud	3S	8W	21	W½		13	Okaw	j
W254	Randolph	Red Bud	4S	8W	4	NW		8	Okaw	a
S1	Randolph	Chester	7S	7W	23	NW	NE	73	Okaw	c
K23	Randolph	Roots	6S	8W	12	NW			Okaw	j
K8	Randolph	Chester	7S	7W	28				Okaw	j
S7	Randolph	Cora	8S	5W	17	NW	SE	17	Menard	c
K13B	Randolph	Chester	7S	6W	30	NW		40	Menard	j
S9	Randolph	Rockwood	8S	5W	18	NW	SE	19	Clore	f
NF80	St. Clair	French Village	2N	9W	24	NW	NE	5	Caprock No. 6 coal	e
NF84	St. Clair	Centerville	1N	9W	3	NW	NW	6	St. David	e
				Clays and Shales						
S22	Monroe	Valmeyer	3S	11W	10	NE	NW	22	Maquoketa	f
S3	Randolph	Chester	7S	7W	23	NW	NE	3	Okaw	f
S11	Randolph	Chester	7S	7W	15	NE	NW	10	Menard	c
S14	Randolph	Chester	7S	7W	15	NE	NW	29	Menard	f
S4	Randolph	Chester	7S	7W	23	NW	NE	20	Loess	f
L9	Randolph	Prairie du Rocher	5S	9W	20				Loess	b
				DISTRICT 4						
				Limestones						
E	Alexander	Thebes	15S	3W	17				Kimmswick	f
L37	Alexander	Thebes	15S	3W	21	NE	NW	25	Girardeau	f
NF449	Alexander	McClure	14S	3W	12	SE	NW	24	Bainbridge	c
NF93, 94	Union	Reynoldsville	13S	2W	20	N½	N½	130	Bailey	f
L53	Jackson	Grand Tower	10S	4W	23	E½	E½	45	Backbone	f
NF444	Union	Wolf Lake	11S	3W	23	SW	NE	40	Backbone	c
S5	Jackson	Grand Tower	10S	4W	25	NE		15	Grand Tower	a
W285	Union	Jonesboro	13S	2W	1	NE	SE	40	Warsaw-Salem	a
L10	Pulaski	Ullin	14S	1W	14	SW	NE	40	Warsaw-Salem	f
L1	Union	Mountain Glen	12S	2W	2	W½		60	Salem	f
NF443	Union	Mill Creek	13S	1W	17	SW	SW	50	Salem	c
D2	Union	Anna	12S	1W	17	SE		20	Ste. Genevieve	a
U66	Union	Anna	12S	1W	17	SE		37	Ste. Genevieve	a
W304	Johnson	Cypress	14S	2E	1			58	Ste. Genevieve	a
NF177B	Hardin	Shetlerville	12S	7E	35			22	Ste. Genevieve	c

(continued)

SiO_2	Al_2O_3	Al_2O_3 and Fe_2O_3	Fe_2O_3	MgO	CaO	Loss on ignition	Sample No.
			DISTRICT 3				
			Limestones				
24.4		1.23**		1.5	40.2	32.5	NF90
6.84		.90		1.06	50.13	40.38	S21
1.42	.05		.36	.51	54.56	43.26	NF167A
1.55	1.01		.12	.37	54.80	42.71	NF332A
2.35	.79		.22	.63	54.13	42.38	NF332E
1.30		.62		1.24	53.35		L70
9.40	.70		.41	3.68	45.60	40.18	NF163D
2.86	.04		.64	1.89	52.50	42.23	NF163P
.63	.26		.44	.62	54.53	43.62	NF162K
.96	1.54		.06	.53	54.50	43.07	NF331F
4.33		1.28**		1.20	51.30		L66
.69	.35		.18	.49	55.30	43.47	NF330A
.81		.85		1.20	53.63		L67
1.50		2.00		.52	54.04	42.72	W254
8.68		2.39		1.01	48.77	39.65	S1
4.52		2.78		2.39	49.09		K23
3.62		1.00		.89	52.33		K8
15.22		3.31		1.31	48.83	36.60	S7
1.04		2.84		1.42	52.23		K13B
7.92		3.00**		1.02	48.88	39.19	S9
7.0		4.8**		2.9	46.5	38.9	NF80
15.3		3.1**		.6	45.4	36.1	NF84
			Clays and Shales				
56.40	7.09		4.46	2.38	15.18	14.36	S22
55.32	17.84		8.24	3.61	3.76	8.81	S3
57.03	24.33		5.33	2.12	1.61	7.62	S11
63.44	18.30		6.39	2.29	1.52	5.94	S14
72.13	12.02		4.05	1.22	1.85		S4
75.93	11.96		3.48	2.04	2.01	6.05	L9
			DISTRICT 4				
			Limestones				
.47	.19		.17	.24	54.50		E
4.42	.11		.37	.47	49.97		L37
2.82	.90		.35	.69	53.23	41.95	NF449
31.75	2.71		1.59	2.61	33.52		NF93, 94
2.12	.21		.47	.75	51.16		L53
.68	.30		.10	1.81	53.77	43.60	NF444
3.08		1.12		1.26	52.24	42.62	S5
3.30		1.48		1.42	51.82	42.32	W285
1.66	.35		.23	.72	53.04		L10
.72	.20		.10	.35	54.15		L1
.29	.26		.11	.70	55.53	43.23	NF443
1.99		.36		3.74	51.30		D2
1.76		.92		1.02	53.60	43.28	U66
2.04		1.22		1.50	52.72	43.34	W304
.59	.32		.26	.11	55.80	43.42	NF177B

Table 3.—

Sample No.	County	Near	T.	R.	Sec.	¼	¼	Thickness ft.	Formation	Reference*
NF177C	Hardin	Shetlerville	12S	7E	35			32	Ste. Genevieve	c
D16	Johnson	Belknap	14S	2E	1			18	Renault	a
D17	Johnson	Belknap	14S	2E	1			15	Renault	a
L20	Union	Anna	12S	1W	8	N½	NE	18	Paint Creek	c
W308	Johnson	Vienna	13S	3E	16	W½		30	Golconda	a
W319	Pope	Golconda	13S	7E	9			15	Golconda	a
Bu20	Pope	Golconda	13S	6E	26				Golconda	a
L100	Johnson	Flatwoods	13S	4E	12	E½		20	Vienna	c
D48	Pope	Reevesville	13S	5E	31	NE		32	Menard (?)	a
T5	Johnson	Flatwoods	13S	4E	1	SE	NW	32	Menard	f
T1	Johnson	Flatwoods	13S	4E	1	SE	NW	7	Menard	f
K29	Johnson	Bloomfield	12S	3E	16				Kinkaid	j
CH1–2	Saline	Equality	10S	7E	3	SW	NW	10	Kinkaid	c
W1–6	Johnson	Simpson	12S	4E	23	SW	NE	9	Kinkaid	c

Clays and Shales

Sample No.	County	Near	T.	R.	Sec.	¼	¼	Thickness ft.	Formation	Reference*
1	Union	Jonesboro	12S	2W	23	NW	NE	20	Mountain Glen	c
LM14	Union	Mill Creek	13S	2W	26	SE	NE	10	Springville	l
W286	Union	Jonesboro	13S	2W	1	NE	SE	40	Springville	b
L16	Union	Anna	12S	1W	9	NE	SW	16	Renault	f
L11	Union	Cobden	12S	1W	6			10	Renault (?)	b
Bu22	Pope	Golconda	13S	6E	26			5½	Golconda(?)	b
Bu23	Pope	Golconda	13S	6E	26			6½	Golconda	b
T2	Johnson	Flatwoods	13S	4E	1	SE	NW	4	Menard	f
AK	Union	Mountain Glen	11S	2W	35	SW	NW		Cretaceous–kaolin	l
B4	Pulaski	Grand Chain	14S	2E	27	SW	SW	13	Cretaceous–clay	l
FE116	Pulaski	Olmsted	15S	1E	27	NE	SE	10	Porters Creek	l
La3	Pulaski	Olmsted	15S	1E	26	NW	NW	15	Porters Creek	l
B21	Hardin	Eichorn	11S	7E	26	SW	SE	7	Residual clay	l
DS4	Alexander	Gale	15S	3W	4	SE	NW	48	Loess	l
L10	Union	Anna	12S	1W	17	SE		8	Loess	b

DISTRICT 5

Limestones

Sample No.	County	Near	T.	R.	Sec.	¼	¼	Thickness ft.	Formation	Reference*
C2acd	LaSalle	LaSalle	33N	1E	15			15	LaSalle	a
C3abd	LaSalle	Oglesby	32N	2E	6			18	LaSalle	a
Dx17B	LaSalle	Spring Valley	16N	11E	33	NW	SW	12	LaSalle	e
P3	Livingston	Pontiac	28N	5E	16			11	Pontiac	m
P8	Livingston	McDowell	27N	5E	1	NW	NE	15	Pontiac	m
S51ac	Clark	Marshall	11N	11W	6	NW		14	Livingston	a
S9	Clark	Casey	10N	14W	28	NE		15	Livingston	a
S3	Coles	Charleston	12N	10E	5	NW		18	Livingston	a
Bu8	Peoria	Princeville	11N	7E	5	SE		15	Lonsdale	a
DS55	Peoria	Peoria	8N	7E	3	NW	SW	15	Lonsdale	g
NF455	Logan	Lincoln	19N	3W	7			10½	Lonsdale	c
L425	Montgomery	Litchfield	8N	5W	2	SW		10	Shoal Creek	j
NF245	Knox	Farmington	9N	4E	31	SW		3	Caprock No. 6 coal	c
NF79	St. Clair	Freeburg	2S	7W	4	SE		5	Caprock No. 6 coal	e
NF69	Perry	Sunfield	5S	1W	32			7	Caprock No. 6 coal	e

(continued)

SiO_2	Al_2O_3	Al_2O_3 and Fe_2O_3	Fe_2O_3	MgO	CaO	Loss on ignition	Sample No.
4.84	1.59		1.04	2.44	49.76	41.03	NF177C
6.00		1.32		1.75	50.53		D16
5.33		.83		.96	52.17		D17
7.34	.42		.64	1.91	49.06		L20
.96		1.76		.74	53.56	43.20	W308
7.04		2.36		1.60	48.44	40.46	W319
7.66		2.02		.93	49.74	39.85	Bu20
16.04		4.14		4.40	38.96		L100
10.45		1.14		1.28	48.88		D48
12.30	1.53		1.79	2.73	43.42		T5
5.50	3.19		1.53	1.79	48.90		T1
4.74		.74		1.48	51.25		K29
4.17	.73		.48	1.51	51.29	41.38	CH1–2
6.56	1.44		.73	1.80	48.87	39.90	W1–6
			Clays and Shales				
56.88	13.85		5.72	1.83	.70	15.90	1
78.63	11.38		2.33	.79	.10	3.38	LM14
71.24		13.74		1.50	5.32	7.66	W286
46.54	17.85		.43	2.01	14.06		L16
64.78	18.17		6.74	1.69	1.43	5.62	L11
59.97	21.00		7.15	1.58	.60	5.54	Bu22
59.90	20.27		6.80	1.66	1.14	6.70	Bu23
55.46	16.20		5.28	2.82	3.66		T2
51.10	34.01		1.41	.37	.15	11.95	AK
59.60	26.48		2.37	.77	.44	8.03	B4
61.06	15.99		4.50	2.00	.86	13.36	FE116
69.07	11.87		4.36	1.79	.85	10.21	La3
56.96	23.47		8.84	.82	.53	7.92	B21
63.96	13.76		3.27	5.11	5.17	8.82	DS4
73.10	13.45		5.33	2.18	2.12	2.86	L10
			DISTRICT 5				
			Limestones				
7.23		3.82		1.39	47.85	39.83	C2acd
6.05		3.25		.91	49.69	40.35	C3abd
26.4	4.8		2.7	2.4	32.1		Dx17B
5.44	.28		.90	.13	50.11		P3
1.12	.29		.65	.19	53.40		P8
1.90		1.97		.60	53.06	43.17	S51ac
4.04		2.94		.66	51.26	41.92	S9
3.91		1.56		1.00	52.49		S3
13.36		3.24		.42	46.74	37.94	Bu8
15.27	2.26		1.04	.78	45.15	35.86	DS55
4.21	1.15		.78	.45	51.75	41.42	NF455
1.76	.28		.43	.36	54.02		L425
12.51	4.38		2.84	2.07	42.41	34.41	NF245
28.5	6.18		2.92	1.1	32.4	27.3	NF79
9.8		4.7**		1.3	47.1	38.3	NF69

TABLE 3.—

Sample No.	County	Near	T.	R.	Sec.	¼	¼	Thickness ft.	Formation	Reference*
NF73	Perry	DuQuoin	6S	2W	29	NW	NE	15	Caprock No. 6 coal	e
NF76	Williamson	Fordville	8S	2E	32	SW	SE	4	Caprock No. 6 coal	f
				Clays and Shales						
W79	LaSalle	Ottawa	33N	3E	18	NE	NE	12	Francis Creek shale	f
R215	Fulton	Canton	5N	5E	7	SE	NW	8	Canton shale	f
K2	Madison	Glen Carbon						30±	McLeansboro shale	d
K3	Edwards	Albion						30±	McLeansboro shale	d
K4	Sangamon	Springfield						50±	Trivoli shale	d
K6	Knox	Galesburg						60	Purington shale	d
K7	LaSalle	Streator						30	Shale above No. 7 coal	d
K14	Vermilion	Danville						50±	McLeansboro shale	d
B18	Clay	Louisville	5N	6E	35	SW	NE	2½	Till (weathered)	n
DS101	Ford	Paxton	23N	10E	17	NW	NW	23	Till	f
R216	Peoria	Bartonville	8N	9E	26	SE	NE	9	Loess	f

[a]Bleininger, A. V., Lines, E. F., and Layman, F. E., 1912, Portland-cement resources of Illinois: Illinois Geol. Survey Bull. 17, table I, p. 97–100, and text, p. 77–96.

[b]Bleininger, Lines, and Layman, table II, p. 104, and text, p. 106–113.

[c]Analyses by Geochemistry Section, Illinois State Geological Survey.

[d]Rolfe, C. W., et al., 1908, Paving brick and paving-brick clays of Illinois: Illinois Geol. Survey Bull. 9, table I, p. 284, and text, p. 280–282.

[e]Lamar, J. E., et al., 1934, Rock wool from Illinois mineral resources: Illinois Geol. Survey Bull. 61, table 1, p. 57–64, and text.

[f]Lamar et al., table 12, p. 142–155.

[g]Lamar et al., table 6, p. 118, and text.

(concluded)

SiO_2	Al_2O_3	Al_2O_3 and Fe_2O_3	Fe_2O_3	MgO	CaO	Loss on ignition	Sample No.
26.9	4.92		2.08	2.1	34.0	29.8	NF73
7.7		3.9		5.8	43.0	39.8	NF76
Clays and Shales							
55.64	23.67		4.70	1.77	.31	7.10	W79
68.25	15.36		4.52	1.69	.65	4.56	R215
63.35	16.27		7.56	1.33	1.01	4.75	K2
59.34	15.36		7.10‡	1.82	.76	7.89	K3
60.31	17.74		7.00‡	1.96	.41	6.71	K4
63.62	16.28		5.92‡	1.44	.63	5.88	K6
59.86	17.43		6.52‡	2.32	1.05	6.35	K7
64.09	14.16		5.81‡	1.64	1.69	6.47	K14
79.04	11.04		3.47	.72	.39	3.18	B18
51.03	12.95		4.90	5.92	7.35	13.56	DS101
61.70	9.16		3.10	4.46	6.98	11.46	R216

[h]Rubey, W. W., 1952, Geology and mineral resources of the Hardin and Brussels quadrangles (in Illinois): U. S. Geol. Survey Prof. Paper 218, p. 156–158.

[i]Lamar, J. E., 1937, *in* Contributions of the fifth annual mineral industries conference in 1937: Illinois Geol. Survey Circ. 23, p. 228.

[j]Krey, Frank, and Lamar, J. E., 1925, Limestone resources of Illinois: Illinois Geol. Survey Bull. 46, table 17, p. 312–323.

[k]Lamar, J. E., 1931, Refractory clays in Calhoun and Pike counties: Illinois Geol. Survey Rept. Inv. 22, p. 22.

[l]Lamar, J. E., 1948, Clay and shale resources of extreme southern Illinois: Illinois Geol. Survey Rept. Inv. 128, p. 18.

[m]Lamar, J. E., 1929, The limestone resources of the Pontiac-Fairbury region: Illinois Geol. Survey Rept. Inv. 17, p. 12, 13, and 19.

[n]Grogan, R. M., and Lamar, J. E., 1945, Illinois surface clays as bonding clays for molding sands—an exploratory study: Illinois Geol. Survey Rept. Inv. 104, p. 12.

REFERENCES

Butts, Charles, 1925, Geology and mineral resources of the Equality-Shawneetown area: Illinois Geol. Survey Bull. 47.

Krey, Frank, 1924, Structural reconnaissance of the Mississippi Valley area from Old Monroe, Missouri, to Nauvoo, Illinois: Illinois Geol. Survey Bull. 45.

Lamar, J. E., 1925, Geology and mineral resources of the Carbondale quadrangle: Illinois Geol. Survey Bull. 48.

North, O. S., 1954, Cement; a chapter from *Mineral Facts and Problems*: preprint from U. S. Bureau of Mines Bull. 556.

Rubey, W. W., 1952, Geology and mineral resources of the Hardin and Brussels quadrangles (in Illinois): U. S. Geol. Survey Prof. Paper 218.

Savage, T. E., and Udden, J. A., 1921, Geology and mineral resources of the Milan and Edgington quadrangles: Illinois Geol. Survey Bull. 38C.

Wanless, H. R., 1929, Geology and mineral resources of the Alexis quadrangle: Illinois Geol. Survey Bull. 57.

Weller, J. M., 1940, Geology and oil possibilities of extreme southern Illinois–Union, Johnson, Pope, Hardin, Alexander, Pulaski, and Massac counties: Illinois Geol. Survey Rept. Inv. 71.

Weller, J. M., and Ekblaw, G. E., 1940, Preliminary geologic map of parts of the Alto Pass, Jonesboro, and Thebes quadrangles in Union, Alexander, and Jackson counties: Illinois Geol. Survey Rept. Inv. 70.

Weller, J. M., et al., 1952, Geology of the fluorspar deposits of Illinois: Illinois Geol. Survey Bull. 76.

Weller, Stuart, and Krey, Frank, 1939, Preliminary geologic map of the Mississippian formations in the Dongola, Vienna, and Brownfield quadrangles: Illinois Geol. Survey Rept. Inv. 60.

Weller, Stuart, and Weller, J. M., 1939, Preliminary geological maps of the pre-Pennsylvanian formations in part of southwestern Illinois: Illinois Geol. Survey Rept. Inv. 59.

Weller, Stuart, et al., 1920, Geology of Hardin County and the adjoining part of Pope County: Illinois Geol. Survey Bull. 41.

Workman, L. E., and Gillette, Tracey, 1956, Subsurface stratigraphy of the Kinderhook series in Illinois: Illinois Geol. Survey Rept. Inv. 189.

Worthen, A. H., 1866, Geological Survey of Illinois, v. I: Illinois Geol. Survey.

Illinois State Geological Survey, Report of Investigations 195

34 p., 3 figs., 3 tables, 1956